BalClor™ BWMS Type Approval Test Report

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SunRui Marine Environment Engineering Company

(Formerly SunRui Corrosion and Fouling Control Company)

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Forward

Sunrui Marine Environment Engineering Company has developed BalClor^{TM} ballast water management system. Final Approval of the BWMS was granted to BalClor^{TM} BWMS in October 2010 at MEPC 61. Sunrui Marine Environment Engineering Company has become the first ship ballast water treatment manufacturers in China. The treatment process includes three steps: filter, seawater electrolysis to generate active substances and neutralizing. Main equipment includes Rectifier & Controller, electrolytic unit, neutralization unit, automatic self-cleaning filter and sensor unit (TRO analyzer, Hydrogen and chlorine gas alarm, metering pump etc.)

According to the requirement of G8 on land-based test type approval, Sunrui Marine Environment Engineering Company conducted 10 land-based test cycles under the witness of CCS from 2009-09-18 to 2009-11-29 in Qingdao. Rated capacity is 250 m^3/h. Sunrui Company entrusted Centre of Marine Environmental Measurements, The First Institute of Oceanography, SOA to perform seawater parameters and biological efficacy analysis. At the same time, Sunrui Company entrusted PONY Testing International Group to perform hydrogen and chlorine gas measurement. The results showed these 10 test cycles met requirements of D2 and G8. These 10 test cycles were valid test cycles.

According to the requirement of G8 on ship test type approval, Sunrui Marine Environment Engineering Company conducted ship tests under the witness of CCS from 2010-7-28 to 2011-1-27 at ANPING 3 Bulk Carrier, whose rated capacity of ballast-pump was 720 m^3/h. Rated capacity of BalClor^{TM} is 500-1000m^3/h. Sunrui Company entrusted Centre of Marine Environmental Measurements, The First Institute of Oceanography, SOA to perform seawater parameters and biological efficacy analysis. The results showed that the 2nd test cycle, the 3rd test cycle and the 4th test cycle were three continuous successful test cycles.

According to the requirement of G8 on corrosion experiment and review of IMO GESAMP Group, Sunrui Marine Environment Engineering Company entrusted Testing and verifying center for Ship Materials of China Shipbuilding Industry to perform coated steel corrosion test, uncoated low carbon steel corrosion test, non-metal corrosion test, coating properties corrosion test, passive metal (316L stainless steel and Cu alloy) corrosion test. Test medium is natural seawater and treated water by BalClor^{TM} BWMS. The results showed that there were no obviously accelerated corrosion effect on metal material, non-metal material and coating.

According to the requirement of G8 on environmental testing for electrical and

electronic equipment and GD01 of CCS, Sunrui Marine Environment Engineering Company entrusted Wuhan Electromechanical Products Environment and Reliability Test Detection Center of CSIC and Qingdao Supervision & Testing Center of Product Quality to perform Power supply fluctuation test, Enclosure protection test, low temperature test, high temperature test, damp heat test, vibrations test, Inclination and swing test. The results showed that environmental testing for electrical and electronic equipment for BalClor^{TM} BWMS met requirements of G8 and GD01.

Contents

1. Summary

Sunrui Marine Environment Engineering Company, whose predecessor was Sunrui Corrosion and Fouling Control Company, was found in 2003. It is the wholly owned subsidiary company of China Shipbuilding Industry Company Limited. The headquarter of company is located in Qingdao, with a branch company located in Shanghai, and is engaged in research and development, design, manufacture, engineering and project contracting of corrosion control and water treatment technology as well as products. Sunrui Company develops technologies and products of cathodic protection, electrolytic generation of sodium hypochlorite, ballast water treatment, electrolytic seawater desalination, anti-fouling of ship and marine platforms, ship sewage treatment and coating. The technologies and products have been widely applied in fields of ship and marine engineering, transportation, power station and nuclear power station, oil pipeline and storage, power, petrochemical, municipal facilities and environment protection. Sunrui Company also export its products to U.S., Japan, Netherlands, Australia, Saudi Arabia, Kuwait, Egypt, Indonesia, Singapore, Pakistan, Sri Lanka, Iran, Sudan, HongKong, and so on.

With more than 50 years of research achievements of former Qingdao Branch of Luoyang Ship Material research institute, Sunrui Company has built the excellent technical team in domestic corrosion control and water treatment field, own the world-class test and measurement facilities on corrosion protection and water treatment. Sunrui compiled over 41 State and Military Standards on corrosion control, anti-fouling and marine coating. The products have been granted the Certifications of LR, DNV, BV and CCS, Sunrui Company had been granted Highest Contracting Certification in corrosion control area issued by National Ministry of Construction, and the Certificate of Conformity of Quality (ISO9001:2008), Environment (ISO14001:2004) and Occupational Health and Safety (GB/T28001-2001) Management System Certification issued by China Xinshidai Certification Body. Sunrui Company is also a high and new technology enterprise certificated by Qingdao Municipal Government. Sunrui Company has been engaged in the research and development of sodium hypochlorite Generation for about 20 years and has successfully undertaken sodium hypochlorite generation projects for 12 nuclear power stations and more than 100 power plants, chemical plants, ship and marine platforms.

Sunrui Company try best to become one of the best world-class companies on corrosion control and water treatment with modern management, advanced technologies, high-quality products and service.

Sunrui Marine Environment Engineering Company, whose predecessor was Sunrui Corrosion and Fouling Control Company, has developed BalClor™ ballast water management system. The treatment process includes three steps: filter, seawater electrolysis to generate active substances and neutralizing. When ballasting, the ballast water is firstly filtrated by an automatic self-cleaning filter with 50μm in order to remove most of the plankton and solid particles which their size are larger than 50μm. Then a small stream of seawater flows through an electrolytic unit to produce sodium hypochlorite solution, which is injected back into the main pipeline after degassing. The concentration of total residual oxidant is less than 9.5mg/L. This concentration of active substance can kill the residual planktons, pathogens, larvae or spores etc effectively and it meets regulation D-2. When de-ballasting, sodium thiosulfate solution is added into the treated ballast water to neutralize the residual TRO. The flow of the neutralization reagent is automatically controlled by control system.

Sunrui Company has started the development of ballast water treatment technology since 2006. A prototype BWMS with treatment capacity of 250m^3/h was designed and manufactured in 2007. In accordance with the requirements of G8, a land-based testing facility was established in Qingdao in June, 2008. Then in August 2008, the test of the prototype functions, improvement and test of biological efficacy was conducted. Based on a series of tests, the operating parameters of the equipment had been defined, and the BWMS was developed and improved. In August 2009, the application for basic approval was submitted to IMO. And the Basic Approval was granted to BalClor™ BWMS in March 2010 at MEPC 60. At the same time, application for Final Approval of the BWMS was submitted to IMO in March 2010. And Final Approval of the BWMS was granted to BalClor™ BWMS in October 2010 at MEPC 61. Sunrui Company is the first ship ballast water treatment manufacturers in China, which is grant to Final Approval by IMO.

2. Land-based Testing

2.1 Summary

According to the G8 requirement, Sunrui Company conducted 10 valid land-based test cycles under the witness of CCS from 2009-09-18 to 2009-11-29 in Qingdao. The 10 land-based test cycle tests included biological efficacy analysis and seawater parameters test of two salinity range. At the same time, the concentration of hydrogen and chlorine were measured in two test cycles. Sunrui Company entrusted Centre of

Marine Environmental Measurements, The First Institute of Oceanography, SOA to perform environmental parameters and biological efficacy analysis and test results saw Report ID C0430, C0431, C0432, C0433, C0434, C0435, C0438, C0439, C0440, C0441. Sunrui Company entrusted PONY Testing International Group to perform hydrogen and chlorine measurement and test results saw Report ID 0911024-291～333, 0911094-075～117.

2.2 Test Organization

The First Institute of Oceanography, SOA is a comprehensive oceanographic research institute engaged in applied and basic researches, high technology development and serving the public. The institute aims at promoting the marine science and technology progress and serving the marine management, marine safety and marine economy development and is an important marine science research entity in the national science and technology innovation system. Her main research fields include the distributions and variabilities of natural environmental elements in Chinese seas, their adjacent oceans and polar sea areas, the marine resources and environmental geology, the generating mechanism and prediction method of marine disasters, the variabilities of marine ecology environment, the remote sensing oceanography and marine information system, the assessment, protection and regulation of marine environment, the marine high technology development and marine comprehensive management sciences. The First Institute of Oceanography, SOA is the earliest into national CMA quality management system (certificate Numbers: 2010001317F) and ISO9000 quality certification system of Marine scientific research units.

PONY TEST (Abbreviation for PONY Testing International Group) is reformed from the national scientific research institution. With our strong scientific research background, PONY TEST grows continuously with amazing speed. As a leading and comprehensive testing organization, we have the qualification of CNAS L0412 and CMA, which obtains mutual recognized agreement in 58 countries and regions, including USA, UK, Germany, etc. PONY TEST provides reports which have obtained international approval and credit. Up to now, with over 1000 employees, we have established 6 large laboratories in Beijing, Shanghai, Shenzhen, Qingdao, Tianjin and Ningbo in China, 8 subsidiaries and 29 branches worldwide, across UK, HK etc., which builds an international testing network. In 2007 and 2008, PONY TEST were honored of "Deloitte Technology Fast 50 China" and "Deloitte

Technology Fast 500 Asia Pacific" continuously.

2.3 The results of seawater parameters test and biological efficacy analysis

2.3.1 The results of test cycle 01

2.3.1.1 Results of seawater parameter test see Table 1

Table 1 The results of seawater parameter of test cycle 01

Test Item	Unit	Sample				
		20090918-TC01T-INF	20090918-TC01T-IAT	20090918-TC01C-INF	20090923-TC01T-DIS	20090923-TC01C-DIS
Temperature	℃	24.9	24.9	24.9	24.2	24.2
Salinity	PSU	33.29	33.25	33.42	33.25	33.39
TSS	mg/L	7.43	5.17	6.00	5.35	4.78
Dissolved Oxygen	mg/L	7.03	9.18	7.08	6.86	5.02
pH		8.09	8.11	8.09	8.02	8.00
Turbidity	°	2.9	1.9	2.9	0.8	0.3
DOC	mg/L	4.45	2.69	2.02	4.37	1.35
POC	mg/L	1.77	1.09	2.27	2.71	1.81

2.3.1.2 Results of viable organisms analysis see Table 2

Table 2 The results of viable organisms analysis of test cycle 01

Viable Organisms	Sample				
	20090918-TC01T-INF	20090918-TC01T-IAT	20090918-TC01C-INF	20090923-TC01T-DIS	20090923-TC01C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	2.67×10^5	1324	2.57×10^5	0	4.89×10^4
greater than or equal to 10μm	1.39×10^3	0.02	1.42×10^3	0.001	393

and less than 50μm in minimum dimension, individuals per millilitre					

The influent water 20090918-TC01T-INF consists of 29 species of viable organisms greater than or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 22 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 6 different phyla/divisions; The influent water 20090918-TC01C-INF consists of 28 species of viable organisms greater than or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 20 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 6 different phyla/divisions.

2.3.1.3 Results of the viable bacteria analysis see Table 3

Table 3 The results of the viable bacteria analysis of test cycle 01

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20090918-TC01T-INF	1.55×10^4	>1600	>1600	0
20090918-TC01T-IAT	2	<2	<2	0
20090918-TC01C-INF	1.58×10^4	>1600	>1600	0
20090923-TC01T-DIS	3	<2	<2	0
20090923-TC01C-DIS	1.62×10^4	1600	1600	0

2.3.1.4 Conclusion

In test cycle 01, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.2 The results of test cycle 02

2.3.2.1 Results of seawater parameter test see Table 4

Table 4 The results of seawater parameter of test cycle 02

Test Item	Unit	Sample				
		20090925-TC02T-INF	20090925-TC02T-IAT	20090925-TC02C-INF	20090930-TC02T-DIS	20090930-TC02C-DIS
Temperature	℃	24.2	24.3	24.4	24.4	24.4
Salinity	PSU	34.28	34.30	34.28	34.26	34.24
TSS	mg/L	19.5	8.30	15.60	4.60	10.10
Dissolved Oxygen	mg/L	7.32	9.27	7.33	7.18	5.93
pH		8.02	8.03	8.03	7.96	7.96
Turbidity	°	3.7	3.1	3.4	0.7	0.5
DOC	mg/L	7.53	2.23	4.25	2.52	2.13
POC	mg/L	1.3	0.41	2.22	3.55	5.62

2.3.2.2 Results of viable organisms analysis see Table 5

Table 5 The results of viable organisms analysis of test cycle 02

Viable Organisms	Sample				
	20090925-TC02T-INF	20090925-TC02T-IAT	20090925-TC02C-INF	20090930-TC02T-DIS	20090930-TC02C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	2.37×10^5	838	2.72×10^5	8	338
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	3.01×10^3	71	3.90×10^3	6	204

The influent water 20090925-TC02T-INF consists of 24 species of viable organisms greater than or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 21 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 7 different phyla/divisions; The influent water 20090925-TC02C-INF consists of 24 species of viable organisms greater than or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 22 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 7 different phyla/divisions.

2.3.2.3 Results of the viable bacteria analysis see Table 6

Table 6 The results of the viable bacteria analysis of test cycle 02

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20090925-TC02T-INF	1.89×10^4	>1600	>1600	0
20090925-TC02T-IAT	3	<2	<2	0
20090925-TC02C-INF	1.82×10^4	>1600	>1600	0
20090930-TC02T-DIS	2	<2	<2	0
20090930-TC02C-DIS	1.35×10^4	1600	1600	0

2.3.2.4 Conclusion

In test cycle 02, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.3 The results of test cycle 03

2.3.3.1 Results of seawater parameter test see Table 7

Table 7 The results of seawater parameter of test cycle 03

Test Item	Unit	Sample				
		20091002-TC03T-INF	20091002-TC03T-IAT	20091002-TC03C-INF	20091007-TC03T-DIS	20091007-TC03C-DIS
Temperature	℃	24.2	24.3	24.4	24.4	24.2
Salinity	PSU	33.40	33.40	33.40	33.43	33.40
TSS	mg/L	7.60	6.40	8.40	6.20	11.20
Dissolved Oxygen	mg/L	7.08	8.95	7.77	6.97	5.44
pH		7.99	7.96	8.01	8.03	7.91
Turbidity	°	2.2	2.3	2.6	1.0	0.9
DOC	mg/L	2.84	2.784	2.41	3.83	3.95
POC	mg/L	1.14	1.573	1.716	2.79	2.24

2.3.3.2 Results of viable organisms analysis see Table 8

Table 8 The results of viable organisms analysis of test cycle 03

Viable Organisms	Sample				
	20091002-TC03T-INF	20091002-TC03T-IAT	20091002-TC03C-INF	20091007-TC03T-DIS	20091007-TC03C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	2.28×10^5	682	2.37×10^5	8	404
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	2.78×10^3	70	2.98×10^3	8	306

The influent water 20091002-TC03T-INF consists of 30 species of viable organisms greater than

or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 23 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 7 different phyla/divisions; The influent water 20091002-TC03C-INF consists of 28 species of viable organisms greater than or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 24 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 7 different phyla/divisions.

2.3.3.3 Results of the viable bacteria analysis see Table 9

Table 9 The results of the viable bacteria analysis of test cycle 03

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20091002-TC03T-INF	3.10×10^4	>1600	>1600	0
20091002-TC03T-IAT	3	<2	<2	0
20091002-TC03C-INF	2.95×10^4	>1600	>1600	0
20091007-TC03T-DIS	8	6	9	0
20091007-TC03C-DIS	5.10×10^3	>1600	>1600	0

2.3.3.4 Conclusion

In test cycle 03, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.4 The results of test cycle 04

2.3.4.1 Results of seawater parameter test see Table 10

Table 10 The results of seawater parameter of test cycle 04

Test Item	Unit	Sample				
		20091009-TC04T-INF	20091009-TC04T-IAT	20091009-TC04C-INF	20091014-TC04T-DIS	20091014-TC04C-DIS
Temperature	℃	24.2	23.8	24.0	22.2	22.0
Salinity	PSU	33.04	33.01	33.02	33.00	33.00
TSS	mg/L	9.90	7.70	15.40	9.75	12.72
Dissolved Oxygen	mg/L	7.13	8.35	7.49	7.24	6.61
pH		8.05	8.06	8.05	7.95	7.96
Turbidity	°	3.9	3.0	4.4	1.3	1.1
DOC	mg/L	5.12	4.74	5.29	3.46	3.81
POC	mg/L	3.13	5.23	2.54	2.9	2.47

2.3.4.2 Results of viable organisms analysis see Table 11

Table 11 The results of viable organisms analysis of test cycle 04

Viable Organisms	Sample				
	20091009-TC04T-INF	20091009-TC04T-IAT	20091009-TC04C-INF	20091014-TC04T-DIS	20091014-TC04C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	3.13×10^5	995	2.62×10^5	5	264
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	2.36×10^3	62	1.98×10^3	2	147

The influent water 20091009-TC04T-INF consists of 29 species of viable organisms greater than or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 26 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 7 different phyla/divisions; The influent water 20091009-TC04C-INF consists of 29 species of viable organisms greater than or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 26 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 7 different phyla/divisions.

2.3.4.3 Results of the viable bacteria analysis see Table 12

Table 12 The results of the viable bacteria analysis of test cycle 04

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20091009-TC04T-INF	2.45×10^4	>1600	>1600	0
20091009-TC04T-IAT	2	<2	<2	0
20091009-TC04C-INF	2.55×10^4	>1600	>1600	0
20091014-TC04T-DIS	10	<2	<2	0
20091014-TC04C-DIS	3.10×10^3	>1600	>1600	0

2.3.4.4 Conclusion

In test cycle 04, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.5 The results of test cycle 05

2.3.5.1 Results of seawater parameter test see Table 13

Table 13 The results of seawater parameter of test cycle 05

Test Item	Unit	Sample				
		20091016-TC05T-INF	20091016-TC05T-IAT	20091016-TC05C-INF	20091021-TC05T-DIS	20091021-TC05C-DIS
Temperature	℃	21.8	22.0	21.8	19.8	19.0
Salinity	PSU	21.24	21.29	21.40	21.21	21.48
TSS	mg/L	236	104	313	3.65	2.88
Dissolved Oxygen	mg/L	7.92	9.52	8.12	8.07	3.79
pH		8.01	8.00	7.98	7.94	7.68
Turbidity	°	3.9	3.6	4.2	1.5	1.1
DOC	mg/L	42.30	14.48	56.70	13.6	13.9
POC	mg/L	14.79	7.34	22.89	6.34	5.4

2.3.5.2 Results of viable organisms analysis see Table 14

Table 14 The results of viable organisms analysis of test cycle 05

Viable Organisms	Sample				
	20091016-TC05T-INF	20091016-TC05T-IAT	20091016-TC05C-INF	20091021-TC05T-DIS	20091021-TC05C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	2.80×10^5	1223	2.95×10^5	1	339
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	4.12×10^3	517	4.00×10^3	3	398

The influent water 20091016-TC05T-INF consists of 25 species of viable organisms greater than

or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 28 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 7 different phyla/divisions; The influent water 20091016-TC05C-INF consists of 26 species of viable organisms greater than or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 26 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 7 different phyla/divisions.

2.3.5.3 Results of the viable bacteria analysis see Table 15

Table 15 The results of the viable bacteria analysis of test cycle 05

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20091016-TC05T-INF	2.12×10^4	>1600	>1600	10
20091016-TC05T-IAT	3	<2	<2	0
20091016-TC05C-INF	2.23×10^4	>1600	>1600	12
20091021-TC05T-DIS	8	23	13	0
20091021-TC05C-DIS	3.51×10^3	>1600	>1600	6

2.3.5.4 Conclusion

In test cycle 05, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.6 The results of test cycle 06

2.3.6.1 Results of seawater parameter test see Table 16

Table 16 The results of seawater parameter of test cycle 06

Test Item	Unit	Sample				
		20091023-TC06T-INF	20091023-TC06T-IAT	20091023-TC06C-INF	20091028-TC06T-DIS	20091028-TC06C-DIS
Temperature	℃	19.6	19.6	19.6	20	20
Salinity	PSU	20.87	20.86	20.94	20.87	21.73
TSS	mg/L	112	55	162	5.28	16.38
Dissolved Oxygen	mg/L	8.38	10.22	8.38	7.81	5.90
pH		7.94	7.94	7.91	7.74	7.78
Turbidity	°	20.3	16.3	25.5	1.0	1.4
DOC	mg/L	8.86	9.52	8.43	9.50	8.99
POC	mg/L	5.47	9.78	6.90	2.31	3.02

2.3.6.2 Results of viable organisms analysis see Table 17

Table 17 The results of viable organisms analysis of test cycle 06

Viable Organisms	Sample				
	20091023-TC06T-INF	20091023-TC06T-IAT	20091023-TC06C-INF	20091028-TC06T-DIS	20091028-TC06C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	2.63×10^5	968	2.67×10^5	1	453
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	4.02×10^3	658	3.98×10^3	3	358

The influent water 20091023-TC06T-INF consists of 22 species of viable organisms greater than or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 28 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions; The influent water 20091023-TC06C-INF consists of 22 species of viable organisms greater than or equal to 50μm in minimum dimension from 3 different phyla/divisions, and 26 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions.

2.3.6.3 Results of the viable bacteria analysis see Table 18

Table 18 The results of the viable bacteria analysis of test cycle 06

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20091023-TC06T-INF	1.98×10^4	>1600	>1600	16
20091023-TC06T-IAT	1	<2	<2	0
20091023-TC06C-INF	2.12×10^4	>1600	>1600	15
20091028-TC06T-DIS	6	<2	<2	0
20091028-TC06C-DIS	2.01×10^3	920	350	8

2.3.6.4 Conclusion

In test cycle 06, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.7 The results of test cycle 07

2.3.7.1 Results of seawater parameter test see Table 19

Table 19 The results of seawater parameter of test cycle 07

Test Item	Unit	Sample				
		20091101-TC07T-INF	20091101-TC07T-IAT	20091101-TC07C-INF	20091106-TC07T-DIS	20091106-TC07C-DIS
Temperature	℃	17.8	17.6	17.0	15.0	14.4
Salinity	PSU	33.30	33.15	33.16	33.17	33.14
TSS	mg/L	2.18	1.50	1.38	11.00	8.75
Dissolved Oxygen	mg/L	8.69	10.09	8.71	9.22	7.30
pH		8.17	8.25	8.17	8.07	7.99
Turbidity	°	3.3	3.2	1.6	1.4	0.5
DOC	mg/L	5.22	3.31	3.82	2.85	1.57
POC	mg/L	3.72	1.49	2.92	3.90	3.17

2.3.7.2 Results of viable organisms analysis see Table 20

Table 20 The results of viable organisms analysis of test cycle 07

Viable Organisms	Sample				
	20091101-TC07T-INF	20091101-TC07T-IAT	20091101-TC07C-INF	20091106-TC07T-DIS	20091106-TC07C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	2.60×10^5	1041	2.62×10^5	4	370
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	4.60×10^3	1021	4.18×10^3	3	442

The influent water 20091101-TC07T-INF consists of 21 species of viable organisms greater than

or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 28 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 6 different phyla/divisions; The influent water 20091101-TC07C-INF consists of 21 species of viable organisms greater than or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 25 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions.

2.3.7.3 Results of the viable bacteria analysis see Table 21

Table 21 The results of the viable bacteria analysis of test cycle 07

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20091101-TC07T-INF	2.30×10^4	＞1600	＞1600	12
20091101-TC07T-IAT	5	＜2	＜2	0
20091101-TC07C-INF	2.22×10^4	＞1600	＞1600	13
20091106-TC07T-DIS	7	＜2	＜2	0
20091106-TC07C-DIS	3.5×10^3	920	240	5

2.3.7.4 Conclusion

In test cycle 07, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.8 The results of test cycle 08

2.3.8.1 Results of seawater parameter test see Table 22

Table 22 The results of seawater parameter of test cycle 08

Test Item	Unit	Sample				
		20091109-TC08T-INF	20091109-TC08T-IAT	20091109-TC08C-INF	20091114-TC08T-DIS	20091114-TC08C-DIS
Temperature	℃	16.2	15.6	16	9.6	9.0
Salinity	PSU	21.67	21.60	21.73	21.64	21.75
TSS	mg/L	103.00	9.80	155.00	25.00	66.11
Dissolved Oxygen	mg/L	8.92	10.58	8.95	8.37	6.88
pH		8.00	8.13	7.98	7.84	7.70
Turbidity	°	34.3	4.8	33.8	2.4	0.8
DOC	mg/L	6.41	5.07	6.08	3.81	2.29
POC	mg/L	5.67	3.50	5.04	0.94	1.77

2.3.8.2 Results of viable organisms analysis see Table 23

Table 23 The results of viable organisms analysis of test cycle 08

Viable Organisms	Sample				
	20091109-TC08T-INF	20091109-TC08T-IAT	20091109-TC08C-INF	20091114-TC08T-DIS	20091114-TC08C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	2.13×10^5	895	2.12×10^5	2	283
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	4.64×10^3	1006	4.38×10^3	3	415

The influent water 20091109-TC08T-INF consists of 23 species of viable organisms greater than

or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 27 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions; The influent water 20091109-TC08C-INF consists of 22 species of viable organisms greater than or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 26 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions.

2.3.8.3 Results of the viable bacteria analysis see Table 24

Table 24 The results of the viable bacteria analysis of test cycle 08

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20091109-TC08T-INF	1.03×10^4	>1600	>1600	8
20091109-TC08T-IAT	20	14	<2	0
20091109-TC08C-INF	1.01×10^4	>1600	>1600	6
20091114-TC08T-DIS	13	2	<2	0
20091114-TC08C-DIS	3.3×10^3	1600	430	2

2.3.8.4 Conclusion

In test cycle 08, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.9 The results of test cycle 09

2.3.9.1 Results of seawater parameter test see Table 25

Table 25 The results of seawater parameter of test cycle 09

Test Item	Unit	Sample				
		20091117 -TC09T-INF	20091117- TC09T-IAT	20091117- TC09C-INF	20091122 -TC09T-DIS	20091122- TC09C-DIS
Temperature	℃	13.0	12.8	12.8	7.2	7.2
Salinity	PSU	21.91	21.89	21.92	21.87	21.93
TSS	mg/L	221	3.78	210	6.67	4.67
Dissolved Oxygen	mg/L	10.58	12.19	10.76	10.26	9.10
pH		7.89	8.02	7.92	7.94	7.80
Turbidity	°	26.2	1.2	22.5	1.6	2.5
DOC	mg/L	10.70	5.61	11.90	3.53	4.20
POC	mg/L	7.08	3.61	6.60	2.54	3.33

2.3.9.2 Results of viable organisms analysis see Table 26

Table 26 The results of viable organisms analysis of test cycle 09

Viable Organisms	Sample				
	20091117-TC09T-INF	20091117-TC09T-IAT	20091117-TC09C-INF	20091122-TC09T-DIS	20091122-TC09C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	2.04×10^5	949	2.01×10^5	1	320
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	3.98×10^3	1001	4.06×10^3	3	404

The influent water 20091117-TC09T-INF consists of 23 species of viable organisms greater than

or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 26 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions; The influent water 20091117-TC09C-INF consists of 24 species of viable organisms greater than or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 28 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions.

2.3.9.3 Results of the viable bacteria analysis see Table 27

Table 27 The results of the viable bacteria analysis of test cycle 09

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20091117-TC09T-INF	1.02×10^4	>1600	>1600	6
20091117-TC09T-IAT	30	4	<2	0
20091117-TC09C-INF	1.10×10^4	>1600	>1600	6
20091122-TC09T-DIS	13	8	<2	0
20091122-TC09C-DIS	1.8×10^3	1600	1600	2

2.3.9.4 Conclusion

In test cycle 09, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.3.10 The results of test cycle 10

2.3.10.1 Results of seawater parameter test see Table 28

Table 28 The results of seawater parameter of test cycle 10

Test Item	Unit	Sample				
		20091124-TC10T-INF	20091124-TC10T-IAT	20091124-TC10C-INF	20091129-TC10T-DIS	20091129-TC10C-DIS
Temperature	℃	9.4	9.4	9.6	7.8	7.8
Salinity	PSU	21.46	21.45	21.33	21.42	21.29
TSS	mg/L	130.00	2.44	183.00	6.89	7.22
Dissolved Oxygen	mg/L	9.92	11.76	9.90	10.78	8.07
pH		7.93	8.08	7.97	7.94	7.72
Turbidity	°	63.4	1.9	61.3	0.4	0.2
DOC	mg/L	10.85	1.63	10.42	4.84	1.68
POC	mg/L	5.68	1.70	6.33	2.54	1.97

2.3.10.2 Results of viable organisms analysis see Table 29

Table 29 The results of viable organisms analysis of test cycle 10

Viable Organisms	Sample				
	20091124-TC10T-INF	20091124-TC10T-IAT	20091124-TC10C-INF	20091129-TC10T-DIS	20091129-TC10C-DIS
greater than or equal to 50μm in minimum dimension, individuals per cubic meter	1.85×10^5	783	1.90×10^5	4	377
greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per millilitre	3.92×10^3	1013	3.86×10^3	3	402

The influent water 20091124-TC10T-INF consists of 24 species of viable organisms greater than

or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 25 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions; The influent water 20091124-TC10C-INF consists of 23 species of viable organisms greater than or equal to 50μm in minimum dimension from 4 different phyla/divisions, and 27 species of viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension from 5 different phyla/divisions.

2.3.10.3 Results of the viable bacteria analysis see Table 30

Table 30 The results of the viable bacteria analysis of test cycle 10

Sample	Test Item			
	Heterotrophic bacteria (CFU/mL)	*Escherichia coli* (CFU/100ml)	Intestinal *Enterococci* (CFU/100ml)	*Vibrio cholerae* (serotypes O1 and O139) (CFU/100ml)
20091124-TC10T-INF	2.43×10^4	>1600	>1600	0
20091124-TC10T-IAT	3	<2	<2	0
20091124-TC10C-INF	2.30×10^4	>1600	>1600	0
20091129-TC10T-DIS	3	2	<2	0
20091129-TC10C-DIS	2.3×10^3	1600	1600	0

2.3.10.4 Conclusion

In test cycle 10, the test results showed that the performance of the influent water, treated water and control water met the requirements of G8.

2.4 The results of hydrogen and chlorine gas measurement

2.4.1 Results of hydrogen and chlorine gas measurement of test cycle 07

Table 31 Hydrogen gas measurements in the surrounding of the BalClor™ BWMS in the test cycle 07

Test time	Concentration of hydrogen gas in the surrounding of BWMS, v/v %
Before electrolysis	<0.04
0.5h after the beginning of electrolysis	<0.04
1h after the beginning of electrolysis	<0.04
2h after the end of electrolysis	<0.04
3h after the end of electrolysis	<0.04
6h after the end of electrolysis	<0.04
24h after the end of electrolysis	<0.04

Table 32 Hydrogen gas measurements in the headspace of treated tank in the test cycle 07

Test time	Concentration of hydrogen gas in the headspace of treated tank, v/v %
Before electrolysis	<0.04
0.5h after the beginning of electrolysis	<0.04
1h after the beginning of electrolysis	<0.04
2h after the end of electrolysis	<0.04
3h after the end of electrolysis	<0.04
6h after the end of electrolysis	<0.04
12h after the end of electrolysis	<0.04
24h after the end of electrolysis	<0.04
48h after the end of electrolysis	<0.04
72h after the end of electrolysis	<0.04
96h after the end of electrolysis	<0.04
120h after the end of electrolysis	<0.04

Table 33 Hydrogen gas measurements upon discharge of vent pipe of degas tank in the test cycle 07

Test time	Concentration of hydrogen gas upon discharge of vent pipe of degas tank, v/v %
Before electrolysis	<0.04
0.5h after the beginning of electrolysis	0.24
1h after the beginning of electrolysis	0.20
2h after the end of electrolysis	<0.04
3h after the end of electrolysis	<0.04

Table 34 Chlorine gas measurements in the surrounding of the BalClor™ BWMS in the test cycle 07

Test time	Concentration of chlorine gas in the surrounding of BWMS, mg/m^3
Before electrolysis	<0.2
0.5h after the beginning of electrolysis	<0.2
1h after the beginning of electrolysis	<0.2
2h after the end of electrolysis	<0.2
3h after the end of electrolysis	<0.2
6h after the end of electrolysis	<0.2
24h after the end of electrolysis	<0.2

Table 35 Chlorine gas measurements in the headspace of treated tank in the test cycle 07

Test time	Concentration of chlorine gas in the headspace of treated tank, （mg/m^3）
Before electrolysis	<0.2
0.5h after the beginning of electrolysis	<0.2
1h after the beginning of electrolysis	0.3
2h after the end of electrolysis	<0.2
3h after the end of electrolysis	<0.2
6h after the end of electrolysis	<0.2

12h after the end of electrolysis	<0.2
24h after the end of electrolysis	<0.2
48h after the end of electrolysis	<0.2
72h after the end of electrolysis	<0.2
96h after the end of electrolysis	<0.2
120h after the end of electrolysis	<0.2

2.4.2 Results of hydrogen and chlorine gas measurement of test cycle 08

Table 36 Hydrogen gas measurements in the surrounding of the BalClor™ BWMS in the test cycle 08

Test time	Concentration of hydrogen gas in the surrounding of BWMS, v/v %
Before electrolysis	<0.04
0.5h after the beginning of electrolysis	<0.04
1h after the beginning of electrolysis	<0.04
2h after the end of electrolysis	<0.04
3h after the end of electrolysis	<0.04
6h after the end of electrolysis	<0.04
24h after the end of electrolysis	<0.04

Table 37 Hydrogen gas measurements in the headspace of treated tank in the test cycle 08

Test time	Concentration of hydrogen gas in the headspace of treated tank, v/v %
Before electrolysis	<0.04
0.5h after the beginning of electrolysis	<0.04
1h after the beginning of electrolysis	<0.04
2h after the end of electrolysis	<0.04
3h after the end of electrolysis	<0.04

6h after the end of electrolysis	<0.04
12h after the end of electrolysis	<0.04
24h after the end of electrolysis	<0.04
48h after the end of electrolysis	<0.04
72h after the end of electrolysis	<0.04
96h after the end of electrolysis	<0.04
120h after the end of electrolysis	<0.04

Table 38 Hydrogen gas measurements upon discharge of vent pipe of degas tank in the test cycle 08

Test time	Concentration of hydrogen gas upon discharge of vent pipe of degas tank, v/v %
Before electrolysis	<0.04
0.5h after the beginning of electrolysis	0.28
1h after the beginning of electrolysis	0.24
2h after the end of electrolysis	<0.04
3h after the end of electrolysis	<0.04

Table 39 Chlorine gas measurements in the surrounding of the BalClor™ BWMS in the test cycle 08

Test time	Concentration of chlorine gas in the surrounding of BWMS, mg/m^3
Before electrolysis	<0.2
0.5h after the beginning of electrolysis	<0.2
1h after the beginning of electrolysis	<0.2
2h after the end of electrolysis	<0.2
3h after the end of electrolysis	<0.2
6h after the end of electrolysis	<0.2
24h after the end of electrolysis	<0.2

Table 40 Chlorine gas measurements in the headspace of treated tank in the test cycle 08

Test time	Concentration of chlorine gas in the headspace of treated tank, mg/m^3
Before electrolysis	<0.2
0.5h after the beginning of electrolysis	<0.2
1h after the beginning of electrolysis	0.3
2h after the end of electrolysis	<0.2
3h after the end of electrolysis	<0.2
6h after the end of electrolysis	<0.2
12h after the end of electrolysis	<0.2
24h after the end of electrolysis	<0.2
48h after the end of electrolysis	<0.2
72h after the end of electrolysis	<0.2
96h after the end of electrolysis	<0.2
120h after the end of electrolysis	<0.2

2.4.3 Conclusion

The hydrogen gas didn't been detected in the surrounding of the BalClor™ BWMS and headspace of treated tank from Table 31,32,33 and Table 36,37,38. The detection limit of measurement equipment is 0.04 v/v %. The concentration of hydrogen upon discharge of vent pipe of degas tank was not more than 0.28 v/v %. It was far below explosion limit. So it was safe.

The chlorine gas didn't been detected in the surrounding of the BalClor™ BWMS from Table 34, 35 and Table 39, 40. The detection limit of measurement equipment is 0.2 mg/m^3. The concentration of chlorine headspace of treated tank was not more than 0.3 mg/m^3. It was within safe scope (not more than 1 mg/m^3).Refer to GB 11984-89 chlorine safety procedures.

2.5 Test items and test personals

Table 42 Test items and test personals of land-based test

Test items		Test personals	Test Organization
seawater parameters	Temperature	Xia Sun	Centre of Marine Environmental Measurements, The First Institute of Oceanography, SOA
	Salinity	Xia Sun	
	TSS	Linping Xie	
	Dissolved Oxygen	Xia Sun	
	pH	Linping Xie	
	Turbidity	Xia Sun	
	POC	Linping Xie	
	DOC	Linping Xie	
Organisms	Viable organisms greater than or equal to 50μm in minimum dimension	Ping Sun	
	Viable organisms greater than or equal to 10μm and less than 50μm in minimum dimensio	Ping Sun	
Bacteria	Heterotrophic bacteria	Li Tian	
	Escherichia coli	Li Tian	
	Intestinal *Enterococci*	Li Tian	
	Vibrio cholerae (serotypes O1 and O139)	Li Tian	
Hydrogen gas		Xin Chu	PONY Testing International Group
Chlorine gas		Fengwei Yue	
Responsibility Content		Name	Company.
Responsible for organizing the tests, coordinating the testing organizations involved and field management.		Guangzhou Liu	SunRui Marine Environment Engineering Company
Responsible for Cleaning land-based set-up and assisting the test organizations to sample.		Xuelei Liu	
Responsible for operation of ballast water treatment system.		Zhilei Wang	

Responsible for assisting the test organizations to sample. Check the quantities and serial number of samples.	Haitao Wang	
Responsible for preparation of influent water and assisting the test organizations to sample.	Qing Yu	
Responsible for record of operational parameters of facilities and concentration of TRO.	Hui Ding	
Witness the test process, China classification society to witness	Haiyang Cui	Qingdao Branch of China Classification Society
Witness the test process, China classification society to witness	Xiaokun Cao	

3. Shipboard tests

3.1 Overview

According to G8 request, shipboard tests must been conducted for the Type Approval of the ballast water management system. The ship board tests must span a trial period of not less than six months and is requested to perform three consecutive valid test cycles in the trial period. BalClorTM BWMS had been installed in ANPING 3 bulk carrier on June 2010 which is affiliated to China Shipping Development Co., Ltd Tramp Co. The cargo capacity of ANPING 3 bulk carrier is 35,000 tons and the rated flow of the ballast water pump is 720m3/h. The treatment rated capacity of BalClorTM BWMS installed in the bulk carrier is 500-1000m3/h.

Shipboard tests commenced on 29 July 2010 and took place in South China Sea and Bohai Sea. Five test cycles had been conducted and all the test cycles were overseen by China Classification Society (CCS). According to G8, biological efficacy and environmental parameters analysis had been conducted. The running of system equipments had been recorded and hydrogen gas, chlorine gas had also been measured. The agency of biological efficacy and environmental parameters analysis is the Centre of Marine Environmental Measurements, the First Institute of Oceanography, SOA. The tests results were listed in the tests reports of the Centre of Marine Environmental Measurements, the First Institute of Oceanography, SOA (Report No.: C0374, C0375, C0376, C0377).

3.2 Test Organization

The test organization is the Centre of Marine Environmental Measurements, the First Institute of Oceanography, SOA. The introduction is in section 2.2.

3.3 The main test results and records

3.3.1 The first test cycle of shipboard tests

3.3.1.1 Results of seawater parameter measurement are listed in table 43

Table 43 Results of seawater parameter measurement of the first shipboard test cycle

Items	Unit	Samples					
		TC01T-INF-EP-1	TC01T-INF-EP-2	TC01T-INF-EP-3	TC01C-INF-EP-1	TC01C-INF-EP-2	TC01C-INF-EP-3
Temperature	℃	30.2	30.2	30.1	30.2	30.2	30.1
Salinity	PSU	28.2	28.5	28.1	28.1	28.3	28.0
TSS	mg/L	2.22	1.68	1.96	1.72	1.12	1.60
POC	mg/L	0.414	0.406	0.386	0.596	0.308	0.443

3.3.1.2 Results of viable organisms analysis are listed in table 44.

Table 44 Results of viable organisms analysis of the first shipboard test cycle

Lot No.	viable organisms greater than or equal to 50μm in minimum dimension, individuals per cubic meter	Lot No.	viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per milliliter
TC01T-INF-50u	500	TC01T-INF-10u	5
TC01C-INF-50u	482	TC01C-INF-10u	5
TC01T-DIS-BEG-50u	6	TC01T-DIS-BEG-10u	2
TC01T-DIS-MID-50u	6	TC01T-DIS-MID-10u	1
TC01T-DIS-END-50u	8	TC01T-DIS-END-10u	1
TC01C-DIS-50u	234	TC01C-DIS-10u	4

3.3.1.3 Results of the viable bacteria analysis are listed in table 45

Table 45 Results of the viable bacteria analysis of the first shipboard test cycle

Lot NO.	Test Items		
	Escherichia coli CFU/100ml	Intestinal *Enterococci* CFU/100ml	*Vibrio cholerae* (serotypes O1 and O139) CFU/100ml
TC01T-INF	31	17	22
TC01C-INF	33	17	18
TC01T-DIS-BEG	<2	<2	0
TC01T-DIS-MID	<2	<2	0
TC01T-DIS-END	<2	<2	0
TC01C-DIS	34	14	26

3.3.1.4 The records of Hydrogen gas and Chlorine gas measurement

Table 46 Results of Hydrogen gas measurement of the first shipboard test cycle（v/v%）

Position	Arounding the equipment	Treatment tank vent	Degas tank vent
Before electrolyzing	0	0	0
Beginning of electrolyzing	0	0	0.8%
Intermediate stage of electrolyzing	0	0	0.9%
End stage of electrolyzing	0	0	0.9%

Table 47 Results of Chlorine gas measurement of the first shipboard test cycle(mg/m^3)

Position	Arounding the equipment	Treatment tank vent	Degas tank vent
Before electrolyzing	0	0	0
Beginning of electrolyzing	0	0	0
Intermediate stage of electrolyzing	0	0	0
End stage of electrolyzing	0	0	0

3.3.1.5 Records of other information

(1) The first shipboard test cycle took place in South China Sea and didn't meet bad weather. The ballasting data is 28 July 2010 and the discharging data is 29 July 2010. The flow of ballast water is 600m^3/h and the amount of ballasting or de-ballasting is 700×2 m^3.

(2) There were no records of schedule and non-schedule maintenance during the firstshipboard test cycle.

(3) During the first shipboard test cycle, control equipments and test control equipments properly.

(4) The data of the first shipboard test cycle can be displayed and stored for 24 months. If the control equipments are replaced, a method can be provided to ensure that the data before the replacement can be stored on board for 24 months.

3.3.1.6 Summary

The results showed that during the first shipboard test cycle, the influent water and the discharged water of the control tank didn't meet the G8 requirements and when discharging, the treated ballast water met the regulation D-2 requirements. According to the related requirements, the first test cycle was invalid.

3.3.2 The second test cycle of shipboard tests

3.3.2.1 Results of seawater parameter measurement are listed in table 48

Table 48 Results of seawater parameter measurement of the second shipboard test cycle

Items	Unit	Samples					
		TC02T-INF-EP-1	TC02T-INF-EP-2	TC02T-INF-EP-3	TC02C-INF-EP-1	TC02C-INF-EP-2	TC02C-INF-EP-3
temperature	℃	23.5	23.5	23.5	23.5	23.5	23.5
salinity	PSU	32.2	32.3	32.6	32.18	32.32	32.64
TSS	mg/L	11.2	14.0	7.0	10.6	14.8	9.8
POC	mg/L	0.620	0.488	0.546	0.697	0.502	0.620

3.3.2.2 Results of viable organisms analysis are listed in table 49.

Table 49 Results of viable organisms analysis of the second shipboard test cycle

Lot No.	viable organisms greater than or equal to 50μm in minimum dimension, individuals per cubic meter	Lot No.	viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per milliliter
TC02T-INF-50u	707	TC02T-INF-10u	144
TC02C-INF-50u	702	TC02C-INF-10u	128
TC02T-DIS-BEG-50u	3	TC02T-DIS-BEG-10u	2
TC02T-DIS-MID-50u	2	TC02T-DIS-MID-10u	2
TC02T-DIS-END-50u	2	TC02T-DIS-END-10u	2
TC02C-DIS-50u	418	TC02C-DIS-10u	58

3.3.2.3 Results of the viable bacteria analysis are listed in table 50

Table 50 Results of the viable bacteria analysis of the second shipboard test cycle

Lot No.	Test Items		
	Escherichia coli CFU/100ml	Intestinal *Enterococci* CFU/100ml	*Vibrio cholerae* (serotypes O1 and O139) CFU/100ml
TC02T-INF	350	11	130
TC02C-INF	350	11	110
TC02T-DIS-BEG	<2	<2	0
TC02T-DIS-MID	<2	<2	0
TC02T-DIS-END	<2	<2	0
TC02C-DIS	350	11	140

3.3.2.4 Records of other information

(1) The second shipboard test cycle took place in Bohai Sea(Qinghuangdao) and didn't meet bad weather. The ballasting data is 13 August 2010 and the discharging data is 14 August 2010. The flow of ballast water is 600m^3/h and the amount of ballasting or de-ballasting is 700×2 m^3.

(2) There were no records of schedule and non-schedule maintenance during the second shipboard test cycle.

(3) During the second shipboard test cycle, control equipments and test control equipments properly.

(4) The data of the second shipboard test cycle can be displayed and stored for 24 months. If the control equipments are replaced, a method can be provided to ensure that the data before the replacement can be stored on board for 24 months.

3.3.2.5 Summary

The results showed that during the second shipboard test cycle, the influent water, the

discharged water of the control tank and the treated ballast water met the G8 requirements. The second shipboard test cycle was valid and successful test cycle.

3.3.3 The third test cycle of shipboard tests

3.3.3.1 Results of seawater parameter measurement are listed in table 51

Table 51 Results of seawater parameter measurement of the third shipboard test cycle

Items	Unit	Samples					
		TC03T-INF-EP-1	TC03T-INF-EP-2	TC03T-INF-EP-3	TC03C-INF-EP-1	TC03C-INF-EP-2	TC03C-INF-EP-3
Temperature	℃	23	23	23	23	23	23
Salinity	PSU	30.8	30.8	30.4	30.4	30.2	30.5
TSS	mg/L	6.75	8.75	7.50	9.50	9.00	7.75
POC	mg/L	0.28	0.22	0.15	0.14	0.18	0.19

3.3.3.2 Results of viable organisms analysis are listed in table 52.

Table 52 Results of viable organisms analysis of the third shipboard test cycle

Lot No.	viable organisms greater than or equal to 50μm in minimum dimension, individuals per cubic meter	Lot No.	viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per milliliter
TC03T-INF-50u	616	TC03T-INF-10u	131
TC03C-INF-50u	663	TC03C-INF-10u	116
TC03T-DIS-BEG-50u	3	TC03T-DIS-BEG-10u	2
TC03T-DIS-MID-50u	2	TC03T-DIS-MID-10u	2
TC03T-DIS-END-50u	2	TC03T-DIS-END-10u	1
TC03C-DIS-50u	361	TC03C-DIS-10u	46

3.3.3.3 Results of the viable bacteria analysis are listed in table 53

Table 53 Results of the viable bacteria analysis of the third shipboard test cycle

Lot No.	Test Items		
	Escherichia coli CFU/100ml	Intestinal *Enterococci* CFU/100ml	*Vibrio cholerae* (serotypes O1 and O139) CFU/100ml
TC03T-INF	920	18	155
TC03C-INF	920	20	150
TC03T-DIS-BEG	<2	<2	0
TC03T-DIS-MID	<2	<2	0
TC03T-DIS-END	<2	<2	0
TC03C-DIS	920	15	170

3.3.3.4 Records of other information

(1) The third shipboard test cycle took place in Bohai Sea(Qinghuangdao) and didn't meet bad weather. The ballasting data is 9 September 2010 and the discharging data is 10 September 2010. The flow of ballast water is 600m^3/h and the amount of ballasting or de-ballasting is 700×2 m^3.

(2) There were no records of schedule and non-schedule maintenance during the third shipboard test cycle.

(3) During the third shipboard test cycle, control equipments and test control equipments properly.

(4) The data of the third shipboard test cycle can be displayed and stored for 24 months. If the control equipments are replaced, a method can be provided to ensure that the data before the replacement can be stored on board for 24 months.

3.3.3.5 Summary

The results showed that during the third shipboard test cycle, the influent water, the discharged water of the control tank and the treated ballast water met the G8 requirements. The third shipboard test cycle was valid and successful test cycle.

3.3.4 The fourth test cycle of shipboard tests

3.3.4.1 Results of seawater parameter measurement are listed in table 54

Table 54 Results of seawater parameter measurement of the fourth shipboard test cycle

Items	Unit	Samples					
		TC04T-INF-EP-1	TC04T-INF-EP-2	TC04T-INF-EP-3	TC04C-INF-EP-1	TC04C-INF-EP-2	TC04C-INF-EP-3
Temperature	℃	19.6	19.5	19.6	19.4	19.4	19.8
Salinity	PSU	28.9	30.2	30.2	30.0	30.3	30.0
TSS	mg/L	4.0	3.2	3.0	6.3	3.5	3.6
POC	mg/L	0.24	0.21	0.21	0.29	0.24	0.28

3.3.4.2 Results of viable organisms analysis are listed in table 55.

Table 55 Results of viable organisms analysis of the fourth shipboard test cycle

Lot No.	viable organisms greater than or equal to 50μm in minimum dimension, individuals per cubic meter	Lot No.	viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension, individuals per milliliter
TC04T-INF-50u	627	TC04T-INF-10u	158
TC04C-INF-50u	618	TC04C-INF-10u	162
TC04T-DIS-BEG-50u	2	TC04T-DIS-BEG-10u	3
TC04T-DIS-MID-50u	2	TC04T-DIS-MID-10u	3
TC04T-DIS-END-50u	1	TC04T-DIS-END-10u	2
TC04C-DIS-50u	437	TC04C-DIS-10u	70

3.3.4.3 Results of the viable bacteria analysis are listed in table 56

Table 56 Results of the viable bacteria analysis of the fourth shipboard test cycle

Lot No.	Test Items		
	Escherichia coli CFU/100ml	Intestinal *Enterococci* CFU/100ml	*Vibrio cholerae* (serotypes O1 and O139) CFU/100ml
TC04T-INF	540	12	140
TC04C-INF	540	12	135
TC04T-DIS-BEG	<2	<2	0
TC04T-DIS-MID	<2	<2	0
TC04T-DIS-END	<2	<2	0
TC04C-DIS	350	9	165

3.3.4.4 Records of other information

(1) The fourth shipboard test cycle took place in Bohai Sea(Qinghuangdao) and didn't meet bad weather. The ballasting data is 13 October 2010 and the discharging data is 14 October 2010. The flow of ballast water is 600m^3/h and the amount of ballasting or de-ballasting is 700×2 m^3.

(2) There were no records of schedule and non-schedule maintenance during the fourth shipboard test cycle.

(3) During the fourth shipboard test cycle, control equipments and test control equipments properly.

The data of the four shipboard test cycle can be displayed and stored for 24 months. If the control equipments are replaced, a method can be provided to ensure that the data before the replacement can be stored on board for 24 months.

3.3.4.5 Summary

The results showed that during the fourth shipboard test cycle, the influent water, the

discharged water of the control tank and the treated ballast water met the G8 requirements. The third shipboard test cycle was valid and successful test cycle.

3.3.5 The fifth shipboard test cycle

The fifth shipboard test cycle took place in the sea area of Dongfang city, Hainan Province and the test date is 27 January 2011 (test period is no less than 6 months). In the fifth test cycle, the ballast water management system is in normal state. Due to the bad weather, the test was forced to stop midway and was the unsuccessful test cycle.

3.4 Test Items and Analysts

Table 57 Test items and analysts of shipboard test

Test Items		Analysts	Test Organization
Seawater Parameters	Temperature	Lingping Xie	Centre of Marine Environmental Measurements, the First Institute of Oceanography, SOA
	Salinity	Xia Sun	
	TSS	Xia Sun	
	POC	Lingping Xie	
Organisms	Viable organisms greater than or equal to 50μm in minimum dimension	Ping Sun	
	Viable organisms greater than or equal to 10μm and less than 50μm in minimum dimension	Ping Sun	
Bacteria	*Escherichia coli*	Li Tian	
	Intestinal *Enterococci*	Li Tian	
	Vibrio cholerae (serotypes O1 and O139)		
Content of the work		Name	Organization
Project leader, responsible for working out the outline of the shipboard testing and carrying out the plan		Guangzhou Liu	SunRui Marine Enviroment Engineering Company
Installation and adjustment of BalClor™ BWMS		Xuelei Liu	

Operation of the BalClor™ BWMS, detection of hydrogen and chlorine	Zhilei Wang	
Recording the system's running conditions during the shipboard testing and , assisting the test institution on sampling	Hui Ding	
Witness of CCS, overseeing all shipboard test cycles	Haiyang Cui	Qingdao Branch of China Classification Society
Witness of CCS, overseeing all shipboard test cycles	Xiaokun Cao	

4. Corrosion tests

According to the requirements of G8 for the corrosion tests and the review of GESAMP – BWWG to the proposal for Basic Approval, the corrosion tests of coated steel, uncoated low carbon steel, non-metal(NBR nitrile butadiene rubber), coating properties and passive materials (316L stainless steel and Cu alloy) had been conducted. The corrosion medium is natural seawater and the ballast water treated by BalClorTM BWMS. The corrosion tests results indicated that the corrosion rate of metal, non-metal and coating in the ballast water treated by BalClorTM BWMS is at the similar level with that of the materials in nature seawater. The test organization is Testing and verifying center for Ship Materials of China Shipbuilding Industry （CNAS L1357） and the results of the tests were listed in the test reports (report ID: JQ09524FS，JQ10502FS，J10014，C1009021，JQ10503FS，JQ10505FS)

5. The environmental tests of the electrical and electronic sections

According to the requirements of G8 and GD01 for the environmental tests of the electrical and electronic sections, the power supply fluctuation test, enclosure protection test, low temperature test, high temperature test, damp heat test, vibration test, inclination and swing test, insulation resistance measurement and withstand voltage test had been conducted. The test results showed that the electrical and electronic sections of BalClor™ BWMS fully meet the requirements of G8 and GD01. The test organizations are Wuhan Electromechanical Products Environment and Reliability Test Detection Center of CSIC (CNAS L1338) and Qingdao Supervision and Testing Center of Product Quality and the results of the tests were listed in the test reports (report No.: CHKS2010-355，QTC-117000017，QTC-017001122)

6. The testing of the by-pass alarm function of the BWMS (G8 4.5.4)

The test of the by-pass alarm had been conducted on 28 December 2010 and was overseen by the senior surveyor Cui Haiyang. The test showed that, when the system was by-passed, the acousto-optic alarm function was started and the time was recorded. When the by-pass failure was lifted, the light alarm was also lifted and the time was recorded. The by-pass alarm function met the requirements of G8.

7. The testing for the function of automatic record and storage of experimental data （G8 4.13）

The function of automatic record and storage of experimental was tested in the first shipboard test cycle and the whole testing process was overseen by surveyor Cao Xiaokun. The results are listed in table 58.

Table 58 The record sheet of data storage

Testing Items	Recording of the testing results
Whether the system can store data of 24 months and whether the data can be displayed or printed.	YES
If the control equipments are replaced, whether a method can be provided to ensure that the data before the replacement can be stored on board for 24 months.	YES

The results met the requirements of G8.

8. The testing of failure alarm （G8 4.3）

The designers and manufacturers tested the function of equipments failure alarm in the workshop, the testing results showed that in case of any failure compromising the proper operation of the BWMS, audible and visual alarm signals can be give in all stations from which ballast water operations are controlled. The results met the

requirements of G8.

Testing staffs: Zhilei Wang , Xuelei Liu.

9. Alarm signals and protective measures

The alarm signals for BalClor™ BWMS are presented in table 59. When there is an alarm, the alarm content will be displayed on the control panel, and acousto-optic alarm will also start. The acousto-optic alarm signal will disappear after pressing the disappear button.

Table 59 System signals and protection logics

System signal	protection logic
The operation status of the rectifier	If there is a failure in the rectifier, controller stop the electrolytic system and send an alarm signal
Flow at the intake of the electrolytic cell	If the flow at the intake of the electrolytic cell is less than the preset value, the operation of the processing unit will be stopped and an alarm will be sent.
The pressure difference between the inlet and outlet of electrolytic cell	If the pressure difference is great, while the flow is normal, that means there is liquid leakage in electrolytic cell, the controller shall automatically stop ballasting.
Status of air blowers	Two air blowers are alternative to each other. If one is in operation failure, another air blower will continue to operate automatically。
the wind pressure of the degas tank air duct	When the wind pressure is lower than the preset value, the rectifier will be stopped with an alarm sent.
The concentration of hydrogen /chlorine gas in air.	1. The alarm value for the concentration of hydrogen gas in air is 2%. When the concentration is up to 3%, the electrolytic system will be shut off at once. 2. The alarm value for the concentration of chlorine in air is 0.40ppm. When the concentration is up to 0.55ppm, the electrolytic system will be shut off at once.
TRO concentration at the ballast water discharge outlet	When the TRO concentration of the ballast water to be discharged is more than 0.1mg/L (TRO analyzer Z-3001 measurement), the discharging process will automatically stop, and on the control panel, sentence like "TRO concentration is high at the outlet, ballast pump stops" will display on the screen.
Liquid level of neutralizer tank	If the water level is lower than the preset value, the controller will make an alarm, and neutralizer need to be added as soon as possible.